AIDA Framework: Real-Time Correlation and Prediction of Intrusion Detection Alerts

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Introduction – Information Sharing

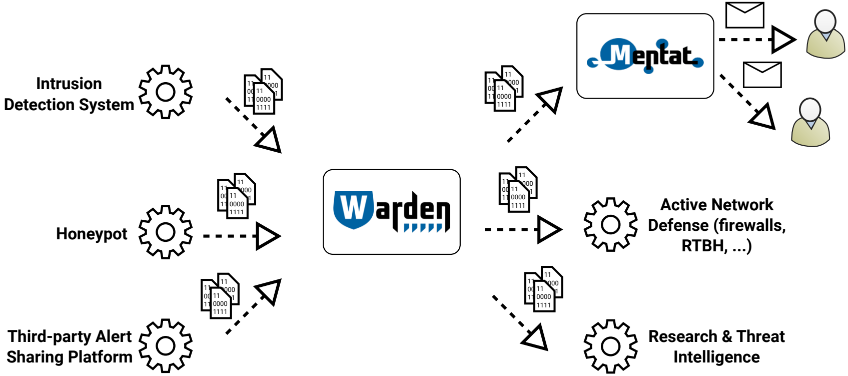
Information Sharing in Cyber Security

- Collaboration and information exchange are fundamental to cyber security
- Automated, effective, and efficient information sharing is still problematic
- Information sharing platforms, e.g., SABU (`https://sabu.cesnet.cz`)

Analysis of Security Alerts

- Large volumes of data from IDS, honeypots, blacklists, . . .
- Heterogeneity of the data – alerts, IoC, vulnerabilities, . . .
- Unclear goals – what to do with the data?

Introduction – SABU Platform



Intrusion Detection System

Honeypot

Third-party Alert Sharing Platform

Warden

Mentat

Active Network Defense (firewalls, RTBH, ...)

Research & Threat Intelligence

Motivation – Blacklisting and Predictions

Personalized Blacklisting

- Receivers of the data are typically interested only in small fraction of them.
- Receivers are not capable of responding to every information in the sharing platform.
- Weekly reports are personalized, but the data are from the past.
- Receivers need small number of items (e.g., IP addresses) that they can react to.

Predictions and projections

- Predicting that an attack will occur, e.g., by time series analysis.
- Projecting the next step of an attacker, e.g., attack matching a known pattern.
- Personalized blacklist can be based on predicted and projected attacks.

AIDA Framework

AIDA Framework

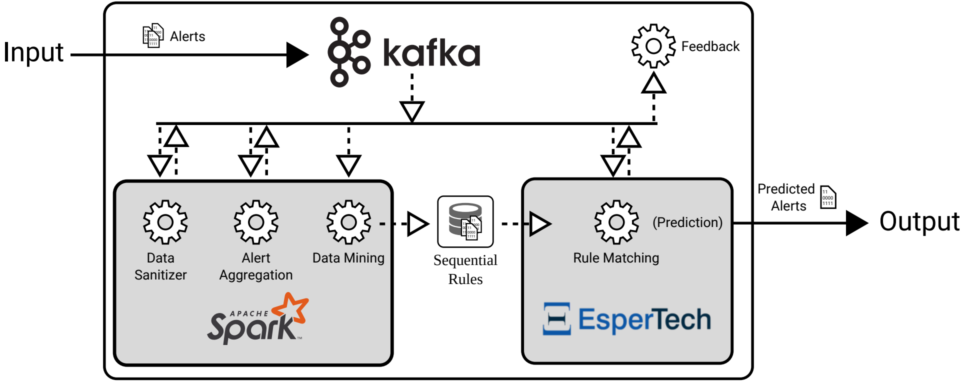
Purpose

- Analytical framework for procesing intrusion detection alerts.
- Motivated by the needs and development of the SABU platform.
- Predictive analytics – attack projections based on historical observations.

Design

- Big Data approaches – stream processing.
- Data mining used to infer predictive rules.
- Complex event processing-inspired rule matching (predictions).

AIDA Framework – Schema



AIDA Framework – Data Distribution

Inputs and Outputs

- Expects messages in IDEA format (`https://idea.cesnet.cz`).
- Deployed version uses Warden client to communicate with the SABU platform.
- Receiving connectors receives alerts, sending connector sends predicted alerts.

Kafka message broker

- Distributes the data in topics to the framework components.
- Ensures correct data order of data processing.

AIDA Framework – Components

Data Sanitization

- Syntactic checks – valid IDEA message (`https://idea.cesnet.cz`).
- Semantic checks – filtering testing messages, alerts with no IP addresses, etc.

Alert Aggregation

- Aggregation of multiple copies of the same alert.
- Aggregation of repeatedly reported events in different time.

AIDA Framework – Information Extraction

Data Mining

- Top-k sequential rule mining.
- Using algorithms implemented in SPMF library.

Predictive rule example

```
OrganizationA.Honeypot1_Recon.Scanning_22,
OrganizationB.IDS1_Attempt.Login_22
==>
OrganizationA.IDS1_Attempt.Login_22
#SUPP: 0.0011 #CONF: 0.6111
```

AIDA Framework – Prediction

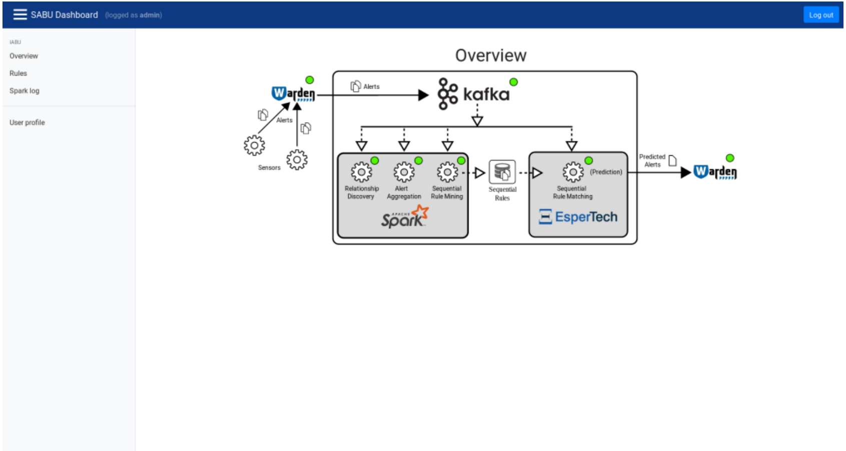
Rule Matching

- Based on Esper – Complex Event Processing engine.
- Esper EPL – SQL-like data stream querying language.
- Predicitve rules are converting to EPL queries.
- If an EPL query finds a match, a new alert is predicted.

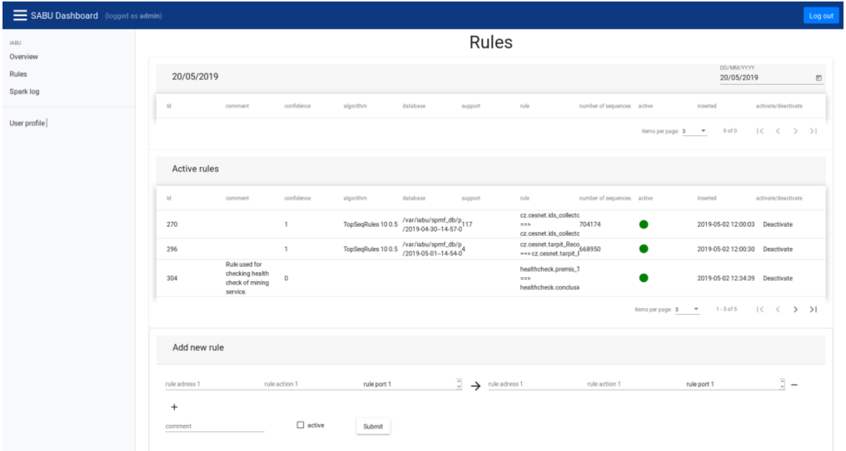
Feedback

- Simple counter and logger of processed and predicted alerts.

AIDA Framework – Dashboard



AIDA Framework – Dashboard



Rules

20/05/2019

DD/MM/YYYY 20/05/2019

id	comment	confidence	algorithm	database	support	rule	number of sequences	active	inserted	activate/deactivate

Items per page: 3 0 of 0

Active rules

id	comment	confidence	algorithm	database	support	rule	number of sequences	active	inserted	activate/deactivate
270		1	TopSeqRules 10 0.5	/var/iabu/spmf_db/p /2019-04-30--14-57-0	117	cz.cesnet.ids_collectc ==> cz.cesnet.ids_collectc	704174	●	2019-05-02 12:00:03	Deactivate
296		1	TopSeqRules 10 0.5	/var/iabu/spmf_db/p /2019-05-01--14-54-0	4	cz.cesnet.tarpit_Reco ==> cz.cesnet.tarpit_I	668950	●	2019-05-02 12:00:30	Deactivate
304	Rule used for checking health check of mining service.	0				healthcheck.premis_T ==> healthcheck.conclusi		●	2019-05-02 12:34:39	Deactivate

Items per page: 3 1 - 3 of 5

Add new rule

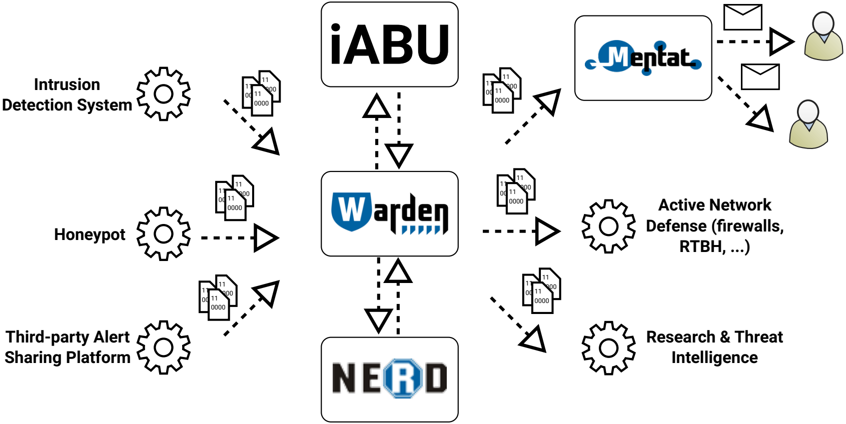
rule adress 1 rule action 1 rule port 1 → rule adress 1 rule action 1 rule port 1 −

+

comment ☐ active Submit

Deployment

Deployment in SABU


Intrusion Detection System
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Deployment in SABU

Data volume and performance

- 1.7 million alerts per day.
- Commondity hardware – 8 CPUs, 16 GB RAM.
- Up to hundred EPL queries running in parallel.

Sample results

- 1.7 million alerts produces around 650,000 sequences.
- Around 55 % of alerts are aggregated.
- Top-10 rules mined every day, approx. 80 % are usable
- Rule confidence most frequently around 0.7, often up to 0.9.

Stand-alone deployment

Running AIDA locally

- AIDA Framework is distributed with a Vagrant file.
- Automated deployment in a virtual machine.
- Still, it is needed to manually trigger data mining and load predictive rules.

Use Case

- Experimentations over datasets
- A sample dataset with alerts from SABU platform was published at `http://dx.doi.org/10.17632/p6tym3fghz.1`

Conclusion

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AIDA Framework

- Analytical framework for processing intrusion detection alerts
- Inspired by the needs of SABU alert sharing platform
- Data mining-supported extraction of common attack patterns
- Predictions of attack continuations; personalized blacklisting

Deployment and Usage

- Operational deployment in the SABU platform
- Stand-alone deployment for experimentation

HTTPS://GITHUB.COM/CSIRT-MU/AIDA-FRAMEWORK

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